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The genus *Moreaua* in Japan and Korea

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Abstract — The *Moreaua* species, distributed in Japan and Korea, are presented. *Moreaua aterrima* is reported for the first time from both countries. *Carex callitrichos* var. *nana, C. mira,* and *C. tenuiformis* are new host records for this smut fungus.

Key words — *Anthracoideaceae, Cyperaceae, Moreaua mauritiana,* taxonomy, *Ustilaginomycetes*

Introduction

Moreaua Liou & H.C. Cheng was described as a monotypic genus typified by *M. kungii* on *Carex* sp. from China (Liou & Cheng 1949). The genus was proposed to accommodate a spore ball forming smut fungus with spore germination intermediate between the classical *Ustilago* and *Tilletia* forms. As originally illustrated (Liou & Cheng 1949: Pls 4–6), the germination produces phragmobasidia that bear terminally or laterally ovoid to ellipsoidal basidiospores, usually with terminal or subterminal basidiospore chains. Because subsequently, chains of basidiospores (cf. single basidiospore at the apex of each phragmobasidium cell) were considered insufficient for establishing a new genus, *M. kungii* was reduced to a synonym of *Thecaphora aterrima* (Wang 1963). The name *Moreaua* remained largely unused in the scientific literature until the 1990s (comp. Vánky 1987, 1994), up to which time *Thecaphora aterrima* was mostly recognized as *Tolyposporium aterrimum* (e.g., Lindeberg 1959, Vánky 1985, 1994, Karatygin & Azbukina 1989).

In the 1990s, it became apparent that *Tolyposporium* was a heterogeneous genus of spore ball forming species (Vánky 1994, 2000). *Thecaphora aterrima, T. apicis* Savile, and all spore ball forming species on *Cyperaceae* described in *Tolyposporium* or transferred from *Sorosporium* to *Tolyposporium* (excluding *T. neillii* (G. Cunn.) Vánky & McKenzie) were removed to the resurrected genus *Moreaua* (Vánky 2000, 2003). In addition, a number of new *Moreaua* species have been recently described (Vánky & Shivas 2001, Piepenbring 2001, Vánky

2002, 2009, Vánky et al. 2009, Shivas et al. 2011). Currently, *Moreaua* comprises 38 species, known mostly from the Southern Hemisphere (33 species), with only seven recorded from the Northern Hemisphere. All species are parasites on host plants in *Cyperaceae*.

Moreaua belongs to *Anthracoideaceae* Denchev. The sori are developed in flowers and form a naked, black, granular-powdery mass of spore balls on the surface of filaments and/or ovaria (in some species also filling aborted and deformed nuts) that are completely hidden by adjacent glumes. Columella, peridium, and sterile cells are lacking. Spore balls are composed of rather firmly cohering spores.

Until the beginning of this study, only one *Moreaua* species, *M. mauritiana,* was known from Japan, reported from the Bonin Islands as *Thecaphora fimbristylidis* (Harada 1979). Later, this record was included in the Kakishima's monograph of the smut fungi in Japan as *Thecaphora aterrima* (Kakishima 1982, see also Katumoto 2010). *Moreaua aterrima* is reported here for the first time from Japan. The current study is a part of an ongoing complete revision of the smut fungi on *Cyperaceae* in Japan (comp. Denchev et al. 2013).

There are no records of *Moreaua* from the Korean Peninsula (Denchev et al. 2007). The three specimens of *Moreaua aterrima* listed here for the first time from South Korea were found by one of us (C.M.D.) during examination of specimens in phanerogamic herbaria in Seoul.

Material & methods

This study is based on examination of specimens from the following dried reference collections: DAOM – National Mycological Herbarium, Agriculture and Agri-Food Canada; SNUA – T.B. Lee Herbarium, College of Agriculture and Life Sciences, Seoul National University, Seoul, S. Korea; SWU – Sungshin Women's University Herbarium, Seoul, S. Korea; and TSH – Laboratory of Plant Parasitic Mycology, Faculty of Life and Environmental Sciences, University of Tsukuba, Tsukuba, Japan.

For LM observations and measurements, spores were mounted in lactophenol solution on glass slides, gently heated to boiling point to rehydrate the spores, and then cooled. In order to count the number of spores in a spore ball and for observation of the spore morphology, the spore balls were bleached in concentrated hydrogen peroxide (H_2O_2) for 10–15 minutes. For SEM, spores were attached to specimen holders by double-sided adhesive tape and coated with gold with an ion sputter. The surface structure of spores was observed at 10 kV accelerating voltage and photographed with a JEOL JSM-5510 scanning electron microscope.

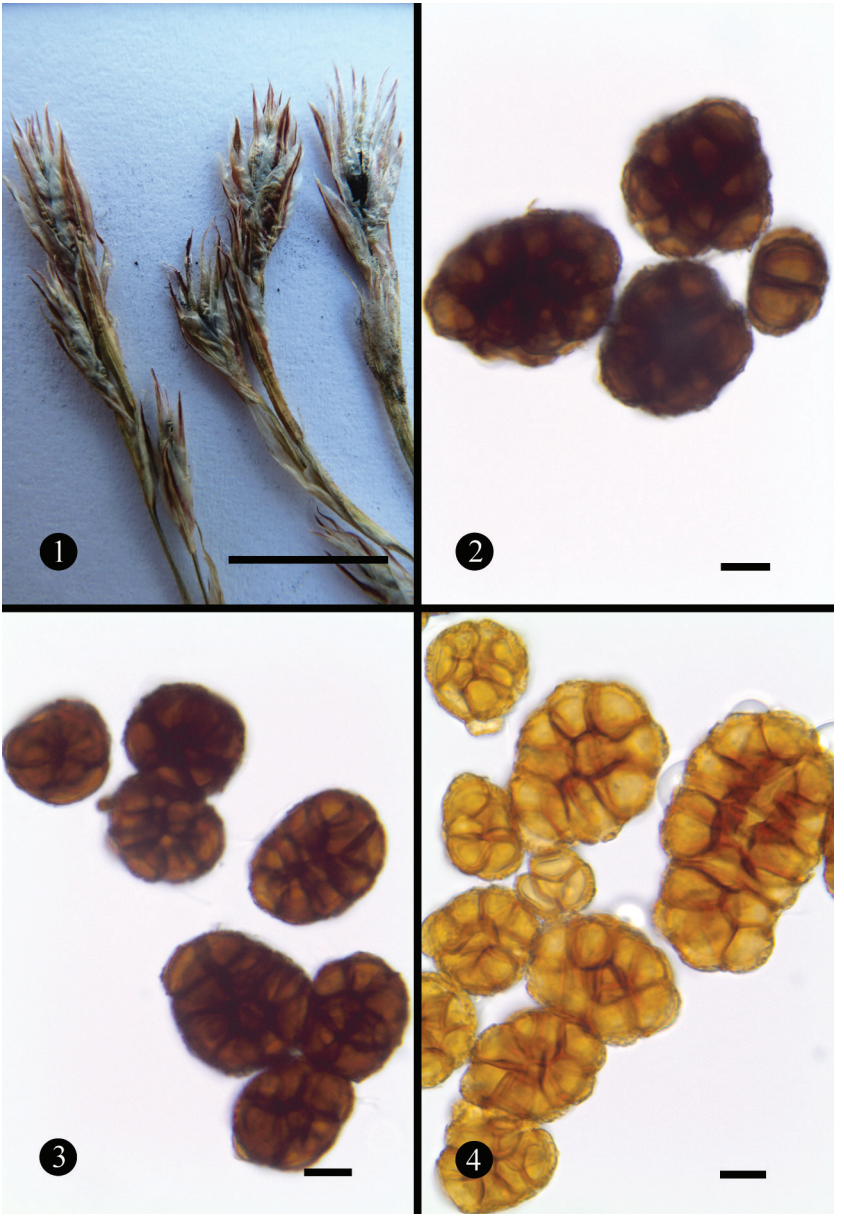
Taxonomy

Moreaua aterrima (Tul. & C. Tul.) Vánky, Mycotaxon 74: 351, 2000. Figs 1–4, 9, 10

≡ *Thecaphora aterrima* Tul. & C. Tul., Ann. Sci. Nat., Bot., Sér. 3, 7: 110, 1847.

≡ *Tolyposporium aterrimum* (Tul. & C. Tul.) Dietel, in Engler & Prantl, Nat. Pflanzenfam. 1(1**): 14, 1897.

= *Moreaua kungii* Liou & H.C. Cheng, Contr. Inst. Bot., Natl. Acad. Peiping 6: 210, 1949.



Figs 1–4. ***Moreaua aterrima*** on ***Carex callitrichos*** var. ***nana*** (SWU): 1. Habit; 2. Spore balls in LM. ***M. aterrima*** on ***Carex lanceolata*** (DAOM 38 528): 3. Spore balls in LM; 4. Spore balls bleached in hydrogen peroxide in LM. Scale bars: 1 = 1 cm; 2–4 = 10 μm.

Sori on filaments and the bases of scales of staminate flowers (spore balls concealed by the staminate scales) or on aborted ovaria (spore balls concealed by the utricles). The mass of spore balls very dark reddish-brown to black, granular-powdery. Infection systemic. Infected female flowers transformed into male flowers with sori. Spore balls globose, subglobose, ovoid, broadly ellipsoidal to slightly irregular, composed of 2–20(–35), firmly united spores, occasionally single spores present, 13.5–45(–56) × 12.5–35(–41) µm, dark reddish-brown or middle reddish-brown when composed of few spores. Spores in surface view broadly elliptical, subglobose, subpolyhedral or irregular, measured from the free side 9.5–17(–18.5) × 8.5–14.5 µm; radially 6.5–17 µm long (on *Carex mira* and *C. tenuiformis* spores in surface view sometimes up to 21 µm long, and radially sometimes up to 22 µm long); wall two-layered, endospore even, 0.6–1.2 µm thick, exospore uneven, 1.1–3.2 µm thick (on *C. mira* 1.0–2.3 µm), much thicker at the free surface than at the contact surfaces, the free surface rather coarsely ornamented as seen by LM & SEM,[1] flattened and smooth on the contact sides.

Specimens examined — On *Carex lanceolata* Boott: **JAPAN, Honshu, Tochigi Pref.,** Mt. Iwafune, 14 May 1950, leg. T. Koyama, det. D.B.O. Savile (as *Thecaphora aterrima,* DAOM 38 528).

On *Carex callitrichos* var. *nana* (H. Lév. & Vaniot) Ohwi (≡ *C. humilis* var. *nana* (H. Lév. & Vaniot) Ohwi; = *C. nanella* Ohwi): **SOUTH KOREA, Gangwon Prov.,** Mt. Samack, 20 Sep 2000, leg. Y.C. Oh, J.Y. Yun & J.K. Lee (SWU, sine num.).

On *Carex mira* Kük.: **SOUTH KOREA, Gangwon Prov.,** Jeongseon-gun, Imgye-myeon, 29 May 1993, leg. T.B. Lee (SNUA 76 476).

On *Carex tenuiformis* H. Lév. & Vaniot: **SOUTH KOREA,** sine loc., sine dat., leg. T.B. Lee (SNUA 51 750).

Distribution — *Moreaua aterrima* is reported from Europe, Asia (East Siberia, Far East of Russia, China, India), North America, and North Africa (Liou & Cheng 1949, Savile 1953, Azbukina et al. 1995, Guo 2000, Vánky 2011, Vánky et al. 2011). It was known to infect 21 species of *Carex.* In East Asia, it has been found only in Kamchatka on *Carex vanheurckii* Müll. Arg. (Azbukina et al. 1995), and in China on *Carex lanceolata* (Guo & Xi 1989, Guo 2000) and *Carex* sp. (Liou & Cheng 1949). *Moreaua aterrima* is reported here for the first time from Japan and the Korean Peninsula. *Carex callitrichos* var. *nana, C. mira,* and *C. tenuiformis* are new host records for this smut fungus.

Moreaua mauritiana (Syd.) Vánky, *Mycotaxon* 74: 352, 2000. Figs 5–8, 11, 12

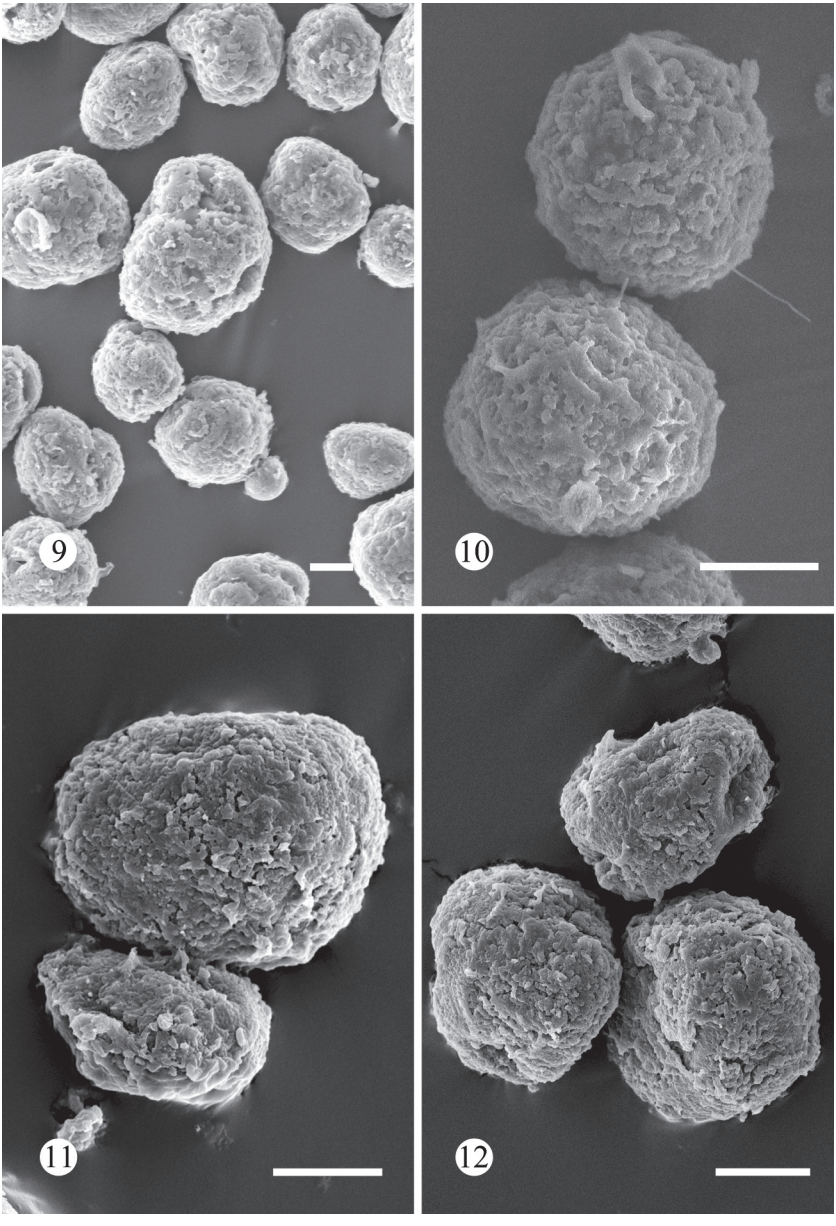
≡ *Tolyposporium mauritianum* Syd., Ann. Mycol. 37: 201, 1939.

≡ *Thecaphora mauritiana* (Syd.) L. Ling, Sydowia 4: 80, 1950.

= *Thecaphora fimbristylidis* Mundk. & Thirum., Mycol. Pap. 16: 4, 1946.

[1] The irregular spore ornamentation of former *Tolyposporium* spp. on *Cyperaceae* was interpreted by Piepenbring et al. (1998: 193) as 'material of adjacent remnants of hyphae and sheaths deposited onto and into the exosporium.'

Figs 5–8. ***Moreaua mauritiana*** on ***Fimbristylis longispica*** var. ***hahajimensis*** (TSH S340): 5. Habit; 6–7. Spore balls in LM; 8. Spore balls bleached in hydrogen peroxide in LM. Scale bars: 5 = 1 cm; 6–8 = 10 μm.



Figs 9–12. ***Moreaua aterrima*** on ***Carex callitrichos*** var. ***nana*** (SWU): 9. Spore balls in SEM. ***M. aterrima*** on ***Carex lanceolata*** (DAOM 38 528): 10. Spore balls in SEM. ***M. mauritiana*** on ***Fimbristylis longispica*** var. ***hahajimensis*** (TSH S340): 11–12. Spore balls in SEM. Scale bars = 10 μm.

Sori around anthers and rudimentary ovaries; in the anthers spore balls replace the pollen grains and anther wall. The mass of spore balls dark reddish-brown, granular-powdery, concealed by the adjacent glumes and outwardly inconspicuous. Infection systemic; all flowers sterile. Spore balls persistent, globose, subglobose, broadly ellipsoidal or irregular, composed of 2–17(–23), firmly united spores, 17–45(–54) × 16–38(–45) µm, sometimes single spores present; dark reddish-brown. Spores in surface view subglobose, subpolyhedral or irregular, radially semi-globose, subcuneiform or irregular; measured from the free side (10.5–)12–18.5(–20) × (9–)10–15(–15.5) µm, radially (6–)7–17(–18.5) µm long; wall two-layered, endospore even, 0.8–1.3 µm thick, exospore uneven, 1.2–3.4 µm thick, much thicker at the free surface than at the contact surfaces, the free surface rather coarsely ornamented as seen by LM & SEM,[2] flattened and smooth on the contact sides.

Specimen examined — On *Fimbristylis longispica* var. *hahajimensis* (Tuyama) Ohwi: **JAPAN, Ogasawara Archipelago (Bonin Islands),** Haha-jima, Oki-mura, 4 Dec 1977, Y. Harada, no. 171 (as *Thecaphora fimbristylidis,* TSH S340).

Distribution — This smut fungus is reported from Africa (Mauritius, Reunion, South Africa), Asia (Japan, India), and Hawaii and is known to infect four species of *Fimbristylis: F. cymosa* subsp. *umbellatocapitata* (Hillebr.) T. Koyama (= *F. cymosa* var. *pycnocephala* (Hillebr.) Kiik.), *F. longispica* var. *hahajimensis, F. ovata* (Burm. f.) J. Kern (= *F. monostachya* (L.) Hassk.), and *Fimbristylis* sp. (Mundkur & Thirumalachar 1946, Mäkinen 1969, Harada 1979, Vánky 2011, Vánky et al. 2011).

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[2] See previous footnote on page 76.

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